

Calculations

Graphics

The following graphics are from the [CalTester Paper](#) Holden JP, Selbie WS, Stanhope SJ, "A proposed test to support the clinical movement analysis laboratory".

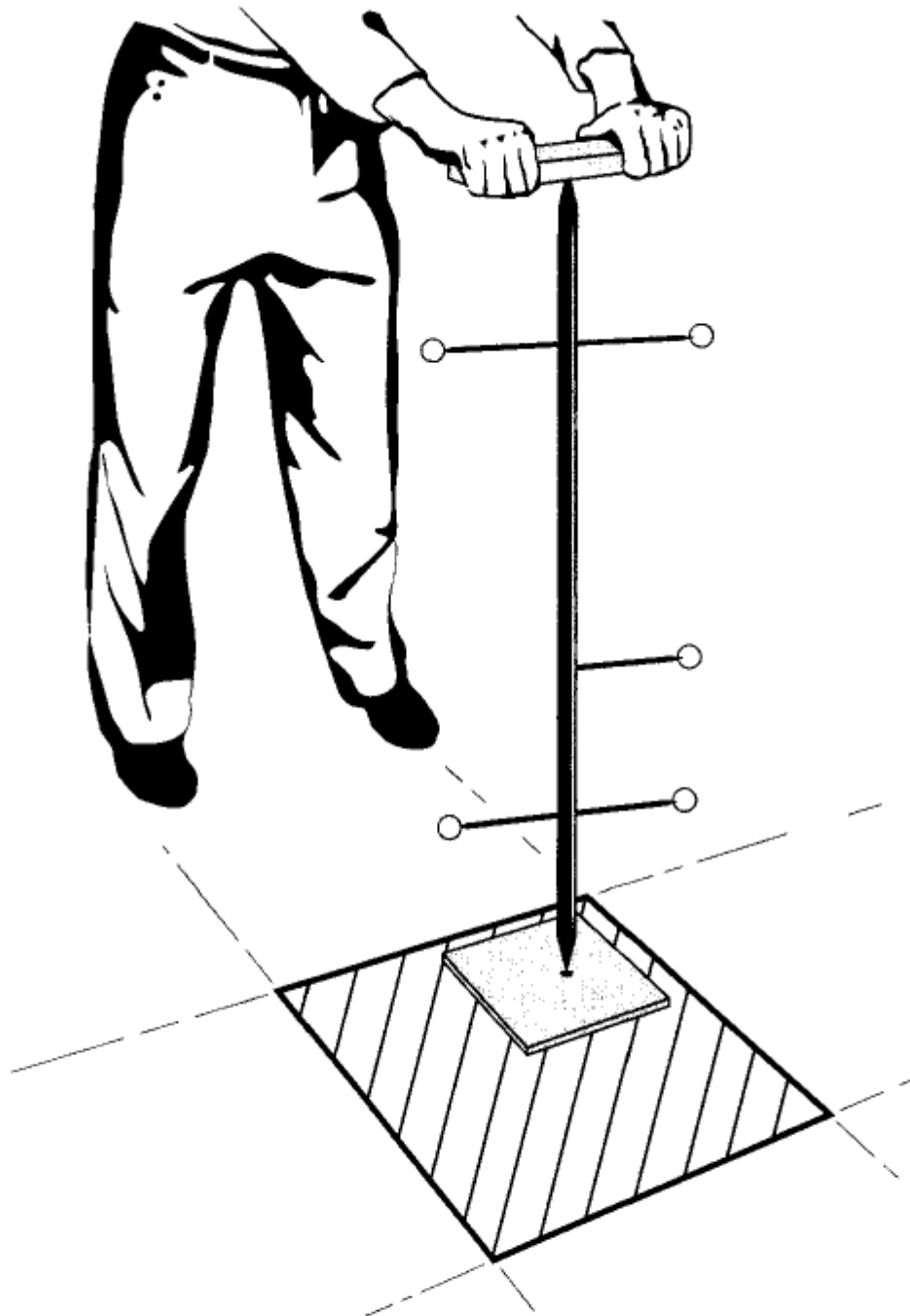


Fig. 1. A rigid mechanical device is used to apply forces to the FP. The device includes spherical, retroreflective targets attached to a machined rod having a pointed tip at each end. Using a hand held loading-bar and base-plate (shaded) with machined conical depressions, one can apply forces to the FP with a negligible applied moment. Data are sampled as the test device is manually loaded and slowly pivoted about the rod end on the base-plate.

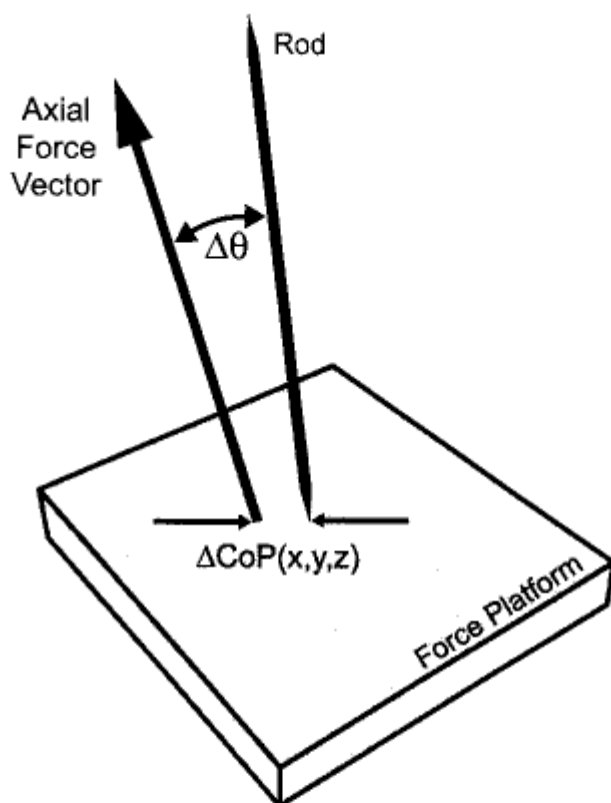


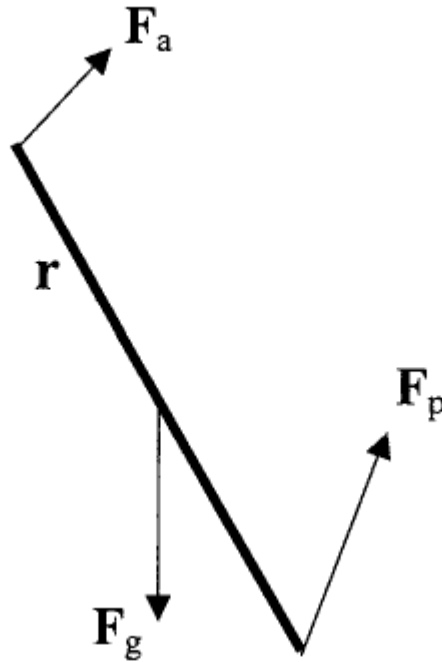
Fig. 2. The four test variables include: the rod orientation variable ($\Delta\theta$), the difference in spatial orientation (angle) of the rod as separately determined from FP measures (axial force vector) and kinematic measures of the rod (Appendix A, section I); and ΔCoP , the differences in the three coordinates of the CoP location, i.e. the x , y , and z components of the displacement vector between the CoP location determined from the FP and the tip of the testing rod as determined from the motion capture system.

Calculations

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Section I : Calculating the rod orientation variable under the assumed condition of static equilibrium

Free-body diagram of testing device: F_p , ground reaction force; F_g , gravitational force (weight); F_a , applied force; r , position vector between tips (p to a) of testing device rod:



$$\sum \mathbf{F} = 0 = \mathbf{F}_p + \mathbf{F}_a + \mathbf{F}_g \quad (1)$$

$$\begin{aligned} \sum \mathbf{T}_p = 0 &= \mathbf{r} \times \mathbf{F}_a + \frac{\mathbf{r}}{2} \times \mathbf{F}_g \\ &= \mathbf{r} \times (-\mathbf{F}_p - \mathbf{F}_g) + \frac{\mathbf{r} \times \mathbf{F}_g}{2} \end{aligned} \quad (2)$$

$$\Rightarrow \mathbf{r} \left(-\mathbf{F}_p - \frac{1}{2} \mathbf{F}_g \right) = \mathbf{r} \times \mathbf{A} = 0 \quad (3)$$

Thus, $\mathbf{r}$ and $\mathbf{A}$ are parallel and the test device rod orientation θ is defined entirely by the vector quantity $\mathbf{A}$ that is derived from FP measurements ($\mathbf{F}_p$) and the physical characteristics of the testing device ($\mathbf{F}_g/2$, i.e. the weight of the rod and its center of mass location; in this case, half the rod length).

$$\Delta\theta = \cos^{-1}(\hat{\mathbf{r}} \cdot \hat{\mathbf{A}})$$

The rod orientation variable ($\Delta\theta$) is determined from the dot product of the unit vector along $\mathbf{A}$ and the unit vector aligned with the long axis of the rod θ as determined using the motion capture components.

Section II : Equation for evaluating the static equilibrium assumption

Under 2D dynamic conditions, the following holds:

$$|r \times A| = \left(\frac{mr^2}{4} + I_{cg} \right) \ddot{\theta} \quad (4)$$

Rewriting the left-hand side of Eq. (4)



Rearranging Eq. (5), the magnitude of the angular displacement (β) between vectors r and A due exclusively to the inertial terms can be isolated:

$$\beta = \sin^{-1} \left[\frac{\left(\frac{mr^2}{4} + I_{cg} \right) \ddot{\theta}}{|r||A|} \right] \quad (6)$$

where r is the length of the testing device rod, I_{cg} the moment of inertia of the test device rod about the center of mass location, m the mass of the testing device rod and $\ddot{\theta}$ is the angular acceleration of the testing device rod relative to an inertial reference frame.

CalTesterPlus does not calculate β since it operates under the assumption that there is no angular acceleration. For this reason it is important to move the CalTester rod slowly at a constant speed.

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